

What is claimed is:

1. An optical wiring substrate comprising:

a substrate;

an optical waveguide being formed on said substrate  
5 and including a core and cladding;

a slab optical waveguide and a planar convex lens  
continuously formed at a tip portion of an optical path  
of said optical waveguide;

a mirror for reflecting said light which transmitted  
10 through said convex lens toward a direction intersecting  
a face of said substrate; and

a lens in which the light reflected with said mirror  
is made as parallel light rays.

2. The optical wiring substrate according to claim 1,  
15 wherein any one of a metallic reflective film and a  
dielectric multilayer film is formed on a surface of said  
mirror.

3. An optical wiring substrate comprising:

a plurality of optical waveguides individually  
20 forming optical paths parallel to one another, each of  
said optical waveguides including cladding, a core, a  
slab optical waveguide, a planar convex lens and a  
reflective mirror; and

one cylindrical lens provided on said optical  
25 waveguides in common for allowing light from each of said  
reflective mirrors provided on each of said optical  
waveguides to pass through and to be made as parallel

light rays.

4. Multilayer optical wiring comprising:

a first optical wiring substrate including:

a first substrate;

5 a first optical waveguide being formed on said substrate and including a core and cladding;

a first slab optical waveguide and a first planar convex lens continuously formed at a tip portion of an optical path of said first optical waveguide;

10 a first mirror for reflecting the light which transmitted through said first planar convex lens toward a direction intersecting a face of said substrate; and

15 a first lens in which said light reflected with said first mirror is made as parallel light rays, and

a second optical wiring substrate including:

a second lens disposed opposite to said first lenses for allowing the parallel light rays from said first lenses to be made incident and condensed;

20 a second substrate;

a second mirror for reflecting the light which transmitted through said second lens toward a direction parallel to a face of said second substrate,

25 a second optical waveguide being formed on said second substrate and including a core and cladding; and

a second planar convex lens and slab optical waveguide continuously formed at a tip portion of an

optical path of said second waveguide for allowing the light reflected with said second mirror to pass therethrough,

wherein optical signals are connected between said  
5 first optical wiring substrate and said second optical wiring substrate.

5. An optical wiring substrate comprising:

a substrate;

a plurality of optical wiring of an input side having  
10 N pieces of input terminals laminated on one face of said substrate; and

a plurality of optical wiring of an output side having N pieces of output terminals laminated on the other side of said substrate and orthogonalized with said  
15 N pieces of the input terminals on said substrate, said plurality of optical wiring of the output side being connected with said plurality of optical wiring of the input side one by one to each other across the different layers at each interlayer transfer position.

20 6. The optical wiring substrate according to claim 5,

wherein said N pieces of the input terminals are provided on a first side of said substrate, and

said N pieces of the output terminals are provided on a second side adjacent to the first side of said  
25 substrate.

7. The optical wiring substrate according to claim 5,

wherein said N pieces of the input terminals are

provided on two opposite sides of said substrate, and

said N pieces of the output terminals are provided on two opposite sides different from said two opposite sides of said substrate.

- 5 8. The optical wiring substrate according to claim 5,  
wherein said optical wiring is an optical waveguides,  
and

10 a pair of slant mirrors opposing to each other for  
orthogonally converting an optical path is provided on  
each of said optical waveguides of said input side and on  
each of said optical waveguides of said output side in  
said interlayer transfer portion between the two layers.

- 15 9. The optical wiring substrate according to claim 5,  
wherein said optical wiring is a set of four-layered  
optical waveguides being laminated via said substrate,  
and

each of core arrangements between the layers is a  
staggered arrangement.

- 20 10. The optical wiring substrate according to claim 5,  
wherein optical fibers are connected to at least any one  
set of said input terminals and said output terminals,  
for supplementing different lengths of optical paths on  
said substrate such that total lengths of said optical  
paths become uniform.

- 25 11. An optical wiring substrate comprising:  
a substrate; and  
a plurality of optical fibers including N pieces of

input terminals on one side of said substrate and N pieces of output terminals on another side thereof, said optical fibers being laid out approximately in L shapes on said substrate.

5 12. The optical wiring substrate according to claim 11, wherein said plurality of optical fibers have positions where said optical fibers are laid out overlapping one another.

10 13. A method of manufacturing an optical wiring substrate comprising the steps of:

forming an under cladding layer on a substrate;

forming a core layer on said under cladding layer;

forming an optical waveguide pattern layer on said core layer;

15 forming a core pattern as optical waveguides by etching with said optical waveguide pattern layer as a mask;

20 forming an over cladding layer after said core pattern is exposed by removing said optical waveguide pattern layer;

forming an incline of approximately  $45^\circ$  as an optical via hole which reaches from said over cladding layer to said substrate; and

25 forming a reflective film on said incline of approximately  $45^\circ$ .

14. A multilayer optical wiring substrate comprising:  
a substrate;

optical waveguides which form different optical wiring layers on upper and lower faces of said substrate; an optical via hole which connects said optical wiring layers; and

5 a communicative portion for communicating an inside of said optical via hole with the outside.

15. The multilayer optical wiring substrate according to claim 14, wherein said communicative portion is any one of a groove and a hole, and is formed on said waveguides.

10 16. The multilayer optical wiring substrate according to claim 14, wherein said communicative portion is any one of a groove and a hole, and is formed on said substrate.

17. The multilayer optical wiring substrate according to claim 14,

15 wherein a plurality of said optical via holes are provided within a cladding layer corresponding to the number of cores, and

said plurality of optical via holes are connected in a manner that at least an adjacent pair of the optical via holes are connected to each other via any one of a groove and a hole provided in common for communicating with the outside.

20 18. The multilayer optical wiring substrate according to claim 14, wherein a plurality of holes severally communicating with said plurality of optical via holes communicate with a vent which is provided perpendicularly from an upper face of said cladding layer.

19. The multilayer optical wiring substrate according to claim 14, wherein said communicative portion is formed on an interface of said optical waveguides and said substrate.

5 20. A multilayer optical wiring substrate comprising:  
a substrate;  
optical waveguides which form different optical wiring layers on upper and lower faces of said substrate;  
an optical via hole which connects said optical  
10 wiring layers;  
a hole for communicating an inside of said optical via hole with the outside; and  
an optical condenser being disposed inside said optical via hole.

15 21. A multilayer optical wiring substrate comprising:  
a substrate;  
optical waveguides being formed on said substrate and including an under cladding layer, a core layer and an over cladding layer,  
20 a pair of slits arranged substantially in parallel on both sides of said core layer, and

at least one groove being provided on said over cladding layer for connecting said pair of slits.

22. The multilayer optical wiring substrate according to  
25 claim 21, wherein at least any one of said slits and said groove communicates with outside air.

23. The multilayer optical wiring substrate according to

claim 21, wherein widths of said slits are narrower than widths of said waveguides.

24. The multilayer optical wiring substrate according to claim 21, wherein said multilayer optical wiring substrate further includes another optical waveguide which intersects said slits almost perpendicularly.

25. A multilayer optical wiring substrate comprising:

a substrate;

a first optical wiring layer including:

optical waveguides being formed on said substrate and including an under cladding layer, a core layer and an over cladding layer;

a pair of slits arranged substantially in parallel on both sides of said core layer; and

at least one groove provided on said over cladding layer for connecting said pair of slits; and

a second optical wiring layer of the same constitution as said first optical wiring layer, being laminated on said first optical wiring layer and including at least a pair of slits communicating with one of said pair of slits of said first optical wiring layer via said groove.

26. A method of manufacturing a multilayer optical wiring substrate comprising the steps of:

forming an under cladding layer on a substrate;

forming a core layer on said under cladding layer;

forming a core pattern as optical waveguides by



etching with an optical waveguide pattern layer formed on said core layer as a mask;

forming an over cladding layer after said core pattern is exposed by removing said optical waveguide pattern layer;

forming a pair of slits substantially in parallel on both sides of said core layer so that said slits reach a surface of said substrate; and

forming at least one groove on said over cladding layer, which communicates with said pair of slits.

27. A multilayer optical wiring substrate comprising:

a substrate;

an optical waveguide layer being formed on one face of said substrate;

a photo acceptance portion being formed on the other face of said substrate; and

an optical interlayer transfer portion provided on said substrate for switching optical paths from said one face to said other face, said interlayer transfer portion including a through hole being formed on said substrate and a lens being formed on at least one face of said substrate formed by layering two kinds of transparent substances each different in refractive index which are filled in said through hole.

28. The optical wiring substrate according to claim 27,

wherein said photo acceptance portion is another optical waveguide layer,

said interlayer transfer portion is an optical via hole, and

said interlayer transfer portion includes:

5 a first transparent substance having a specific refractive index, both upper and lower surfaces of said first transparent substance being formed into concave faces upon being filled into said through hole; and

10 a second transparent substance having a refractive index higher than said refractive index of the first transparent substance, being filled severally into said concave faces, said second transparent substance being formed into concave lenses on said substrate by planarizing surfaces of said second transparent substance along faces of said substrate.

15 29. The optical wiring substrate according to claim 28, wherein concave faces having different curvature to each other are formed on said upper and lower faces formed on the said first transparent substance.

20 30. The optical wiring substrate according to claim 27, wherein said photo acceptance portion is a light receiving element,

said interlayer transfer portion is an optical interface,

25 said through hole has a cross section of a tapered shape in a depth direction of said substrate, and

said concave lenses formed on upper and lower faces of said substrate have different diameters from each

other.

31. The optical wiring substrate according to claim 27,  
wherein said photo acceptance portion is a light  
receiving element,

5       said interlayer transfer portion is an optical  
interface,

a concave lens is formed on one side to which light  
from said optical waveguide is made incident, said  
concave lens including a high-refractive substance, and

10       a low-refractive substance with a refractive index  
lower than a refractive index of said concave lens is  
disposed on the other side, a surface of said low-  
refractive substance being formed into a convex shape.

32. A method of manufacturing an optical wiring  
15       substrate comprising the steps of:

providing a through hole on a substrate;

filling a first transparent substance having a  
specific refractive index in said through hole;

20       forming concave faces respectively on both surfaces  
of said first transparent substance by polishing; and

filling a second transparent substance having a  
refractive index higher than a refractive index of said  
first transparent substance in each of said both concave  
faces.

25       33. The method of manufacturing an optical wiring  
substrate according to claim 32, wherein in the step of  
providing the through hole on the substrate a laser beam

is irradiated in a manner of spiral motion to form a cross section of said through hole into a tapered shape in a depth direction of said substrate.

34. A method of manufacturing an optical wiring substrate comprising the steps of:

providing a through hole on a substrate;

filling resin made of a low-refractive substance into said through hole;

applying pressure from one face of said resin made of a low-refractive substance, to form said one face into a concave shape and to form the other face into a convex shape;

filling resin made of a high-refractive substance into said concave face of said resin made of a low-refractive substance; and

planarizing by polishing said resin made of a high-refractive substance along a face of said substrate.

35. An optical wiring substrate comprising:

a substrate;

an optical waveguide formed on said substrate, said optical waveguide including a core of which a tip portion is formed into a convex shape, and cladding contacting with said core and having a refractive index different from a refractive index of said core, said cladding being provided so as to abut a face of said substrate; and

a cylindrical lens disposed opposite to said convex tip portion of said core such that a center of said core

coincides with a center of curvature of said cylindrical lens.

36. The optical wiring substrate according to claim 35, wherein said convex tip portion of the core is formed with a member having a same refractive index as a refractive index of said core.

37. The optical wiring substrate according to claim 35, wherein said core has a broadened shape toward said tip portion.

38. An optical wiring substrate having an optical connection structure for signals comprising:

a substrate;

a first optical waveguide including a core and cladding which has a refractive index different from a refractive index of said core and covers around said core, said first optical waveguide being supported on said substrate in a state that a tip portion of said core is exposed to air from said cladding; and

a second optical waveguide including a core which has a tip portion exposed to air, being disposed in a position opposite to said tip portion of said first optical waveguide, and cladding which has a refractive index different from a refractive index of said core and covers around said core, said second optical waveguide being supported on said substrate for performing propagation of optical signals with said first optical waveguide.

39. The optical wiring substrate according to claim 38,

wherein said tip portion of said first optical waveguide has a cylindrical face with its central axis in a horizontal direction, and

5        said tip portion of said second optical waveguide has a cylindrical face with its central axis in a vertical direction.

40. An optical wiring substrate comprising:

a substrate;

10        an optical waveguide layer which includes cores and cladding which has a refractive index different from a refractive index of said cores and covers around said cores; and

15        optical transmittance distributive regions being formed axisymmetrically with respect to axial centers of said optical waveguide layers, said optical transmittance distributive regions supporting said cladding by sandwiching.

41. A multilayer optical wiring substrate comprising:

20        a first optical waveguide layer including a plurality of first optical waveguides parallelly arranged along an x-axis, each of said first optical waveguides including a first core and first cladding, and a first optical absorber with low optical transmittance arranged on both  
25        sides of said first optical waveguide axisymmetrically with respect to an axial center of said first core; and

a second optical waveguide layer to be laminated on

said first optical waveguide layer including second optical waveguides parallelly arranged along a y-axis and arranged orthogonally with respect to said first optical waveguides of said first optical waveguide layer, each of  
5 said second optical waveguides including a second core and second cladding, and a second optical absorber with low optical transmittance arranged on both sides of said second optical waveguide axisymmetrically with respect to an axial center of said second core.

10 42. The multilayer optical wiring substrate according to claim 41, further including:

an optical via hole in an intersecting portion of said laminated first optical waveguide and said laminated second optical waveguide, a central position of said  
15 intersecting portion being detected by a difference of optical transmittance in a perpendicular direction from optical transmittance of other parts, said optical via hole being formed for optical propagation between said optical waveguide layers.

20 43. The multilayer optical wiring substrate according to claim 42,

wherein said first optical waveguide and said second optical waveguide are orthogonalized to each other at different layers, and

25 at said optical via hole, coupling faces for optical paths of said first optical waveguide and said second optical waveguides are both formed into cylindrical faces

such that axes of said cylindrical faces are orthogonalized to each other.

44. The multilayer optical wiring substrate according to claim 42,

5        wherein said first optical waveguide and said second optical waveguide are aligned rectilinearly and parallelly at different layers, and

10        at said optical via hole, the coupling faces for the optical paths of said first optical waveguide and said second optical waveguide are both formed as planar mirrors.

45. A method of manufacturing a multilayer optical wiring substrate comprising the steps of:

forming a first cladding layer on a substrate;

15        forming core portions by exposure treatment via a mask after forming a core layer on said cladding layer;

forming a second cladding layer for covering said core portions;

20        forming a third cladding layer on said second cladding layer with a substance having high optical absorptance; and

forming optical transmittance distributive regions axisymmetrically with respect to said cores after planarizing said third cladding layer.